Grade 12: Fields

Curriculum Connections

Physics–University Preparation

IP = Initiating and Planning, PR = Performing and Recording, AI = Analysing and Interpreting, C = Communicating

Physics Curriculum Connections (SPH4U)
Activity 1: What Is a Field?
Scientific Investigation Skills and Career Exploration
– **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
– **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
– **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
– **A1.12** use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation (e.g., vector diagrams, free-body diagrams, vector components, and algebraic equations) [C]
Energy and Momentum
– **C2.1** use appropriate terminology related to energy and momentum, including, but not limited to: *work*, *work–energy theorem*, *kinetic energy*, *gravitational potential energy*, *elastic potential energy*, *thermal energy*, *impulse*, *change in momentum–impulse theorem*, *elastic collision*, and *inelastic collision* [C]
– **C2.6** analyse, in qualitative and quantitative terms, elastic and inelastic collisions in one and two dimensions, using the laws of conservation of momentum and conservation of energy, and solve related problems [PR, AI]
Gravitational, Electric, and Magnetic Fields
– **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
– **D3.2** compare and contrast the corresponding properties of gravitational, electric, and magnetic fields (e.g., the strength of each field; the relationship between charge in electric fields and mass in gravitational fields)
– **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

Physics Curriculum Connections (SPH4U)

Activity 2: Making Electric Fields Real

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.4** apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models) [C]

Gravitational, Electric, and Magnetic Fields

- **D1.1** analyse the operation of a technological system that uses gravitational, electric, or magnetic fields (e.g., a home entertainment system, a computer, magnetic strips on credit cards) [AI, C]
- **D1.2** assess the impact on society and the environment of technologies that use gravitational, electric, or magnetic fields (e.g., satellites used in surveillance or storm tracking, particle accelerators that provide high-energy particles for medical imaging) [AI, C]
- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.3** analyse, and solve problems involving, electric force, field strength, potential energy, and potential as they apply to uniform and non-uniform electric fields (e.g., the fields produced by a parallel plate and by point charges) [AI]
- **D3.2** compare and contrast the corresponding properties of gravitational, electric, and magnetic fields (e.g., the strength of each field; the relationship between charge in electric fields and mass in gravitational fields)
- **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

Physics Curriculum Connections (SPH4U)

Activity 3: Maxwell's Equations

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]
- **A1.12** use appropriate numeric (e.g., SI and imperial units), symbolic, and graphic modes of representation (e.g., vector diagrams, free-body diagrams, vector components, and algebraic equations) [C]
- **A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., laser optics researcher, geoscientist, photonics researcher, aerospace engineer) and the education and training necessary for these careers
- **A2.2** describe the contributions of scientists, including Canadians (e.g., Elizabeth MacGill, Pierre Coulombe, Allan Carswell, Gerhard Herzberg), to the fields under study

Gravitational, Electric, and Magnetic Fields

- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.3** analyse, and solve problems involving, electric force, field strength, potential energy, and potential as they apply to uniform and non-uniform electric fields (e.g., the fields produced by a parallel plate and by point charges) [AI]
- **D2.4** analyse, and solve problems involving, the force on charges moving in a uniform magnetic field (e.g., the force on a current-carrying conductor or a free electron) [AI]
- **D2.5** conduct a laboratory inquiry or computer simulation to examine the behaviour of a particle in a field (e.g., test Coulomb's law; replicate Millikan's experiment or Rutherford's scattering experiment; use a bubble or cloud chamber) [PR]
- **D3.2** compare and contrast the corresponding properties of gravitational, electric, and magnetic fields (e.g., the strength of each field; the relationship between charge in electric fields and mass in gravitational fields)
- **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

The Wave Nature of Light

- **E3.4** describe, in qualitative terms, the production of electromagnetic radiation by an oscillating electric dipole (e.g., a radio transmitter, a microwave emitter, an X-ray emitter, electron energy transitions in an atom)

Physics Curriculum Connections (SPH4U)

Activity 4: Auroras and Interacting Fields

Scientific Investigation Skills and Career Exploration

- **A1.4** apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection [IP]
- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]

Dynamics

- **B2.6** analyse, in qualitative and quantitative terms, the forces acting on and the acceleration experienced by an object in uniform circular motion in horizontal and vertical planes, and use free-body diagrams and algebraic equations to solve related problems [AI, C]
- **B2.7** conduct inquiries into the uniform circular motion of an object (e.g., using video analysis of an amusement park ride, measuring the forces and period of a tether ball), and analyse, in qualitative and quantitative terms, the relationships between centripetal acceleration, centripetal force, radius of orbit, period, frequency, mass, and speed [PR, AI]

Energy and Momentum

- **C2.1** use appropriate terminology related to energy and momentum, including, but not limited to: *work*, *work–energy theorem*, *kinetic energy*, *gravitational potential energy*, *elastic potential energy*, *thermal energy*, *impulse*, *change in momentum–impulse theorem*, *elastic collision*, and *inelastic collision* [C]
- **C2.3** use an inquiry process to analyse, in qualitative and quantitative terms, situations involving work, gravitational potential energy, kinetic energy, thermal energy, and elastic potential energy, in one and two dimensions (e.g., a block sliding along an inclined plane with friction; a cart rising and falling on a roller coaster track; an object, such as a mass attached to a spring pendulum, that undergoes simple harmonic motion), and use the law of conservation of energy to solve related problems [PR, AI]
- **C3.2** describe and explain the simple harmonic motion (SHM) of an object, and explain the relationship between SHM, Hooke's law, and uniform circular motion
- **C3.4** explain the implications of the laws of conservation of energy and conservation of momentum with reference to mechanical systems (e.g., damped harmonic motion in shock absorbers, the impossibility of developing a perpetual motion machine)

Gravitational, Electric, and Magnetic Fields

- **D2.4** analyse, and solve problems involving, the force on charges moving in a uniform magnetic field (e.g., the force on a current-carrying conductor or a free electron) [AI]
- **D3.3** use field diagrams to explain differences in the sources and directions of fields, including, but not limited to, differences between near-Earth and distant fields, parallel plates and point charges, straight line conductors and solenoids

The Wave Nature of Light

- **E3.4** describe, in qualitative terms, the production of electromagnetic radiation by an oscillating electric dipole (e.g., a radio transmitter, a microwave emitter, an X-ray emitter, electron energy transitions in an atom)

Physics Curriculum Connections (SPH4U)

Activity 5: Explaining Mercury's Orbit

Scientific Investigation Skills and Career Exploration

- **A1.1** formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research [IP]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]
- **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge [AI]

Dynamics

- **B2.6** analyse, in qualitative and quantitative terms, the forces acting on and the acceleration experienced by an object in uniform circular motion in horizontal and vertical planes, and use free-body diagrams and algebraic equations to solve related problems [AI, C]

Gravitational, Electric, and Magnetic Fields

- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.2** analyse, and solve problems relating to, Newton's law of universal gravitation and circular motion (e.g., with respect to satellite orbits, black holes, dark matter) [AI]
- **D3.1** identify, and compare the properties of, fundamental forces that are associated with different theories and models of physics (e.g., the theory of general relativity and the standard model of particle physics)

Design Challenge: Using Fields to Go Places

Scientific Investigation Skills and Career Exploration

- **A1.5** conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data [PR]
- **A1.6** compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams [PR]
- **A1.8** synthesize, analyse, interpret, and evaluate qualitative and quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error [AI]

Dynamics

- **B1.1** analyse a technological device that applies the principles of linear or circular motion (e.g., a slingshot, a rocket launcher, a race car, a trebuchet) [AI, C]

Energy and Momentum

- **C1.1** analyse, with reference to the principles of energy and momentum, and propose practical ways to improve, a technology or procedure that applies these principles (e.g., fireworks, rocket propulsion, protective equipment, forensic analysis of vehicle crashes, demolition of buildings) [AI, C]

Gravitational, Electric, and Magnetic Fields

- **D1.1** analyse the operation of a technological system that uses gravitational, electric, or magnetic fields (e.g., a home entertainment system, a computer, magnetic strips on credit cards) [AI, C]
- **D2.1** use appropriate terminology related to fields, including, but not limited to: *forces*, *potential energies*, *potential*, and *exchange particles* [C]
- **D2.3** analyse, and solve problems involving, electric force, field strength, potential energy, and potential as they apply to uniform and non-uniform electric fields (e.g., the fields produced by a parallel plate and by point charges) [AI]
- **D2.4** analyse, and solve problems involving, the force on charges moving in a uniform magnetic field (e.g., the force on a current-carrying conductor or a free electron) [AI]
- **D2.5** conduct a laboratory inquiry or computer simulation to examine the behaviour of a particle in a field (e.g., test Coulomb's law; replicate Millikan's experiment or Rutherford's scattering experiment; use a bubble or cloud chamber) [PR]

Earth and Space Science

IP = Initiating and Planning, PR = Performing and Recording, AI = Analysing and Interpreting, C = Communicating

Earth and Space Science Curriculum Connections (SES4U)
Activity 4: Auroras and Interacting Fields
Planetary Science (Science of the Solar System) – **C2.3** use an inquiry or research process to investigate the effects of various forms of radiation and high-energy particles on bodies, organisms, and devices within the solar system (e.g., the effects of cosmic rays on atmospheric phenomena, of ultraviolet light on human and animal eyes and skin, of solar wind on radio communications) [IP, PR] – **C2.5** investigate the properties of Earth that protect life from hazards such as radiation and collision with other bodies (e.g., Earth's orbital position helps protect it from asteroids, some of which are deflected by the Jovian planets; Earth's magnetic field protects the planet from solar wind; atmospheric ozone minimizes incoming ultraviolet radiation) [PR] – **C3.9** describe the major external processes and phenomena that affect Earth (e.g., radiation and particles from the "quiet" and "active" sun; cosmic rays; gravity of the sun and moon; asteroidal and cometary debris, including their force, energy, and matter)
Activity 5: Explaining Mercury's Orbit
Astronomy (Science of the Universe) – **B1.1** analyse a major milestone in astronomical knowledge or theory (e.g., the discovery of the red shift in the spectra of galaxies; the knowledge gathered from the particle accelerator experiments at CERN in Switzerland), and explain how it revolutionized thinking in the scientific community [AI, C] ***Planetary Science (Science of the Solar System)*** – **C2.1** use appropriate terminology related to planetary science, including, but not limited to: *solar system*, *geocentric*, *heliocentric*, *geodesy*, *geosynchronous*, *eccentricity*, *apogee*, *aphelion*, *perigee*, and *perihelion* [C] – **C2.6** investigate techniques used to study and understand objects in the solar system (e.g., the measurement of gravitational pull on space probes to determine the mass of an object, the use of spectroscopy to study atmospheric compositions, the use of the global positioning system to track plate movement and tectonic activity from space) [PR] – **C3.1** explain the composition of the solar system (e.g., the sun, terrestrial inner planets, the asteroid belt, gas giant outer planets, the Kuiper belt, the scattered disc, the heliopause, the Oort cloud), and describe the characteristics of each component – **C3.7** identify Kepler's laws, and use them to describe planetary motions (e.g., the shape of their orbits; differences in their orbital velocity) – **C3.8** identify Newton's laws, and use them to explain planetary motion